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(54) **Production of aluminium alloy sheet.**

(57) Fine-grained, formable Al-Mn alloy sheet is produced from strip-cast slab (e.g. twin-roll-cast slab) by including 1.3 - 2.3%Mn in the alloy, slab annealing the cast slab by heating at about 450 - 550°C to precipitate most of the Mn in fine intermetallic particles, cold rolling the slab to effect at least 30% cold reduction, inter-annealing the cold-rolled material at a temperature below the recrystallization temperature for a time sufficient to reduce the residual Mn in solid solution to below 0.2% by weight. The inter-annealed material is then preferably subjected to one or more additional cold-rolling stages to reduce it to a final desired thickness and is further annealed after each cold-rolling stage.

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Croydon Printing Company Ltd.

"PRODUCTION OF ALUMINIUM ALLOY SHEET"

This invention relates to processes for producing aluminium alloy sheet from strip-cast slab, and to the products of such processes. The term "sheet" herein will be used generically to refer to those thicknesses which are commonly designated foil (less than 0.15 mm) as well as to those customarily considered sheet (6.0 - 0.15 mm).

As herein contemplated, strip casting is the continuous casting of an aluminium alloy slab having a thickness of not more than about 25 mm., and often substantially less. Various strip casting techniques are known; one such known technique, to which detailed reference will be made herein for purposes of illustration, involves the use of twin-roll type casters, such as the continuous strip casters manufactured by Hunter Engineering Company of Riverside, California. In a twin-roll caster, the molten metal is solidified in the nip of a pair of heavily-chilled steel rolls, which draw the molten metal out of an insulated injector nozzle in close proximity to the rolls, the cast material being in the form of a slab, e.g. in a thickness range of 5 - 10 mm. and being typically cast at a speed of 60 - 200 cm./min. The metal is essentially fully solidified when it passes the centre line of the caster rolls; it is subjected to heavy compression and some plastic deformation as it

passes through the gap between the rolls, with the consequence that its surfaces are in excellent heat exchange contact with the caster rolls and there is some residual strain in the cast strip or slab.

The production of aluminium alloy sheet from strip-cast slab has various advantages, including lower-production costs. It has not been possible to produce fine-grained formable sheet of conventional Al-Mn 1.0% alloys from strip-cast slab, owing to uncontrolled precipitation of Mn-rich particles and resultant preferential growth of relatively few large grains. The presence of large grains, which may be of a size corresponding to the thickness of the sheet in foil-gauge material, can lead to great difficulty in forming the sheet, since each grain deforms differently, which can lead to tearing and/or a crumpled surface. Thus, in making Al-Mn alloy products such as foil e.g. for rigid foil containers, it has been necessary to employ metal, conventionally cast in thick direct-chilled (D.C.) ingots and successively hot-rolled and cold-rolled, to avoid growth of large grains notwithstanding that use of Al-Mn alloy sheet from strip-cast slab would often be economically beneficial if an adequate combination of strength and formability could be attained.

The present invention broadly provides a process for producing an aluminium alloy sheet,

comprising the successive steps of strip-casting a slab of a thickness of no more than about 25 mm. of an Al alloy containing as essential ingredient 1.3 - 2.3% manganese, and optionally up to 0.5% each of iron, magnesium, and copper, up to 0.3% silicon, up to 2.0% zinc, less than 0.1% each of zirconium, chromium, and titanium, other elements up to 0.3% each and up to 1.0% total, (all percentages herein being expressed by weight unless otherwise specified), annealing the cast slab for a time sufficient to precipitate at least 50% of the Mn content out of solid solution, reducing the thickness of the annealed slab by cold rolling by at least 30%; inter-annealing the workpiece by heating at a temperature below its recrystallization temperature for a time such that the workpiece remains substantially free of recrystallization, and further precipitation of Mn from solid solution reduces the Mn content of the Al matrix down to 0.2% or lower. After the inter-annealing stage the workpiece is preferably subjected to further cold rolling to reduce the material to a sheet having a desired final sheet thickness, after which the sheet is subjected to a partial or full final anneal.

In the strip casting step of the process of the invention molten alloy of the specified composition (Mn preferably in the range of 1.5 - 1.8%) is continuously supplied to a type of casting equipment

wherein it is cast into a strip or slab having a thickness of no more than about 25 mm. The practical limitations of casters do not usually permit the slab to be cast commercially at a thickness of less than about 3 mm. For the purpose of the present invention the alloy is cast under conditions to maintain a high proportion of the Mn content in supersaturated solid solution in the as-cast metal so that the casting operation is preferably carried out in a caster in which there is very rapid solidification of the cast metal. It is thus preferred to carry out the casting operation in a caster of the twin-roll type because of the very rapid solidification achieved therein. However, other types of strip caster, such as the twin-belt type described in British Patent No. 1,549,241 or the block-type caster described in United States Patent No. 3,570,586, in which there is a high rate of heat transfer from the cast metal, may be employed in the process. In some instances, particularly where there is no hot reduction in the caster itself, it may be desirable to subject the cast slab to some hot rolling reduction before the slab annealing stage, so as to generate some strain in the cast slab, which assists in the precipitation of the manganese in the subsequent slab annealing stage. However, it is preferred to avoid hot-rolling the as-cast slab, since such rolling stage substantially increases the overall cost of the processing of the alloy.

By virtue of the raised Mn content and the heavy Mn-supersaturation of the as-cast slab, resulting from the mode of casting, slab-annealing results in a dense precipitation of fine Mn-rich intermetallic particles. As is well known the size of particles precipitated from supersaturated solution becomes smaller with increase in the degree of supersaturation by the solute. It is found that the size of the particles precipitated from strip-cast Al alloy having 1.7% Mn content is substantially smaller than the particle size of the precipitate from strip-cast Al alloy having 1.1% Mn treated under the same conditions. It follows that for the high Mn content alloy the Mn-rich particles present after the slab-annealed stage are far higher in number and much more closely spaced. The slab annealing is continued for a time sufficient to precipitate at least 50% of the manganese content as Mn-rich intermetallic particles. It is found that for the highly supersaturated as-cast slab the average particle size is typically in the range of 0.1 - 2 microns and coarse or agglomerated particles are essentially absent.

The slab annealing is usually carried out at a temperature in the range of 450 - 550^{o}C, but may be performed with diminishing effectiveness at temperatures somewhat outside the limits above stated, for example within 400 - 600^{o}C.

The interannealing is performed, as a step for reducing the amount of manganese in solid solution in the aluminium matrix to not more than about 0.2% of the matrix, under conditions of time and temperature mutually selected to effect that result while maintaining the material at least substantially free of recrystallization by which is meant that after interannealing (and before any further cold rolling) it contains not more than about 20% by volume of recrystallized grains. Such conditions are referred to herein as non-recrystallizing conditions.

As a result of the dense precipitation of fine Mn-rich particles in the slab-annealing stage, more of the residual Mn in solid solution can be precipitated by the interanneal performed at a temperature below recrystallization temperature. The distance to be travelled by dissolved Mn to a precipitation site is greatly reduced as a result of the much greater number (and consequently reduction in spacing) of the Mn-rich intermetallic particles, as compared with conventional, more dilute Al-Mn alloys subjected to the same heat treatment.

The Mn in solution will diffuse more rapidly in a non-recrystallized structure than in a recrystallized aluminium matrix because of enhanced diffusion along dislocation and other lattice defects.

Consequently after the interanneal stage the residual Mn content in solid solution is no more than about 0.2% and this low residual Mn content does not cause any difficulties in any final anneal applied after further cold reduction following the interanneal.

Owing to the combination of high Mn content, mode of casting, and heat treatment including the steps of slab annealing, cold reduction following the slab anneal, interannealing without substantial recrystallization, the sheet product of the invention is characterised by a fine grain of subgrain structure with intermetallic particles having an average particle size between about 0.1 and about two microns, and by a yield strength curve (plotted against final annealing temperature) having a shallow slope over a final annealing temperature range of interest (about 250° - 450°C). This shallow slope is advantageous from the standpoint of reproducibility of results, in that small variations in the final annealing time and/or temperature do not give widely different properties. In particular, the process of the invention enables production, from strip-cast (e.g. twin-roll-cast) slab, of Al-Mn alloy sheet exhibiting a combination of properties of strength and formability (as represented by percent elongation) at least about equivalent to sheet of more dilute Al-Mn alloys produced conventionally by the more expensive route involving

casting the alloy as a relatively thick ingot, followed by successive hot- and cold-rolling steps. The method of the invention is very suitable for making sheet, convertible to rigid foil containers. Alternatively, the present process can be used to produce sheet having strength superior to the aforementioned sheet made from conventional thick ingots, with little sacrifice of formability. In addition, the material after the interannealing step (i.e. without performance of the subsequent cold rolling and final annealing steps of the complete process of the invention) is itself a useful sheet product in many instances.

The casting of Al-alloys having a Mn content within the range specified by means of the twin-roller caster, preferred for use in the process of the present invention, has been described in United States Patent No. 4,111,721, but in the subsequent processing the metal was subjected to a special annealing treatment intended to increase the size of the precipitated particles to a large size and there is no subsequent heat treatment stage corresponding to the interanneal herein performed at a temperature below the recrystallization temperature.

In United States Patent No. 3,930,895 an Al-alloy having a high Mn content of the range herein contemplated, but also a Mg content in the range of 0.75 - 1.75% is also cast by means of a twin-roll caster,

but the cast slab is treated to a high temperature treatment, to agglomerate precipitated particles to coarse size in the range of 4-12 microns (the reverse of the purpose of the slab annealing stage in the present process) and are thus ineffective to achieve maximum Mn precipitation in a subsequent anneal after cold-reduction.

Further features and advantages of the invention will be apparent from the detailed description hereinbelow set forth, together with the accompanying drawing.

The single figure is a graph of yield strength plotted against final annealing temperature for an illustrative example of an aluminium alloy sheet produced in accordance with the present invention.

The process of the present invention includes the step of strip-casting a slab of an aluminium alloy having the following composition (general and preferred ranges and limits):

	Range, Maximum (max.) or Nominal (nom.)	
	General (%)	Preferred (%)
Mn	1.3 - 2.3	1.5 - 1.8
Fe	0.5 max.	0.1 - 0.3
Si	0.3 "	0.1 nom.
Mg	0.5 "	0.2 max.
Cu	0.5 "	0.2 "
Zn	2.0 "	2.0 "
Zr	less than 0.1	0.03 "
Cr	" " 0.1	0.03 "
Ti	" " 0.1	0.03 "
others (each/total)	0.3/1.0 max.	0.1/0.5 max.
Al	balance	balance

In a specific example of a presently preferred embodiment of the invention, the alloy used contains 1.5 - 1.8% Mn, 0.1 - 0.3% Fe, about 0.1% Si, and $<$0.03% Mg.

The alloys employed in the invention can be considered Al-Mn alloys, in that the intermetallics formed in these alloys are predominantly Al-Mn intermetallics, and also in that manganese is the principal alloying element, with the possible exception (in some circumstances) of zinc, which does not, however, affect the precipitation of the intermetallics as particles in the desired size range.

It is at present especially preferred to perform the casting step in a twin-roll caster, owing in particular to the markedly superior uniformity of as-cast microstructure thereby achieved. When a twin-roll caster is used, a small amount of hot reduction of the slab occurs in the nip of the caster rolls, but apart from this inherent effect of the caster, the slab is not ordinarily subjected to any hot rolling prior to cold reduction. In the aforementioned exemplary embodiment of the invention, the casting step can be performed on a twin-roll caster of the specific type described above, manufactured by Hunter Engineering Company, to produce a continuous slab; as an illustrative specific example of dimensions, the slab can be 7.6 mm. thick and 1420 mm. wide.

After hot rolling (if any) and prior to any cold working, the slab is annealed in accordance with the invention by heating at a temperature in the range of 450° - 550°C (preferably 500 - 550°C) for a period of one to twentyfour hours (preferably two to six hours) to precipitate most of the manganese of the alloy in manganese-rich intermetallic particles having an average particle size between about 0.1 and about 2 microns (typically about 0.5 micron); in the case of slab cast on a twin-roll caster, wherein there is no hot reduction subsequent to the casting step, the slab is subjected to the slab-annealing operation in as-

cast conditions. This heating step may be performed with equipment conventional for heating strip-cast slab. In the aforementioned specific example the slab-annealing step is performed by heating the slab at 500°C for a period of two to four hours.

After the slab-annealing step, and without any intervening hot working, the slab is cold-rolled in conventional manner to effect a reduction of at least 30% in its thickness. This initial cold rolling stage in the aforementioned specific example, is performed to reduce the workpiece from the as-cast slab thickness of 7.6 mm. to a thickness of 0.76 mm., i.e. to effect a 90% cold reduction.

Following this initial cold rolling stage, the workpiece is interannealed by heating it at a temperature, in a range between about 250° and about 450°C, under conditions of time and temperature for reducing the amount of manganese in solid solution in the aluminium matrix to not more than about 0.2% of the weight of the matrix, while maintaining the material substantially free of recrystallization, i.e. such that the interannealed material contains not more than about 20% by volume of recrystallized grains.

In connection with the interannealing step, "recrystallization temperature" means the maximum temperature at which the material can be heated for a specified time while remaining substantially free

of recrystallization (less than 20% recrystallized grains). Stated generally, the interannealing step of the present process is performed by heating the material to a temperature (within the aforementioned range) which is below the recrystallization temperature for the particular interannealing time selected. It will be appreciated that the recrystallization temperature is time-dependent, i.e. within broad limits, the shorter the interannealing time, the higher the recrystallization temperature. For a given interannealing time, the recrystallization temperature is dependent both on the alloy composition and on the prior treatment (especially the conditions of the slab-annealing operation) of the particular material to be interannealed. Thus, for interannealing times of about two hours, temperatures in the upper portion of the above-stated temperature range (e.g. around 425°C) for the interannealing step may be above the recrystallization temperature of some materials, especially those which have been slab-annealed at temperatures substantially above 500°C or which have a relatively high content of iron, but where this is a high manganese content (1.7% and higher) and a low iron content (below 0.2%), recrystallization does not occur upon heating for two hours at 425°C. The recrystallization temperature for any material and preselected interanneal treatment time is readily

determinable by simple practical test and examination of a treated specimen. Once the recrystallization temperature has been thus determined, an interannealing temperature is selected which is below that recrystallization temperature but within the stated temperature range.

The interannealing step of the invention can be performed in any convenient way, for example, as a fast, continuous anneal of the cold-rolled strip, or as a slower batch anneal of a batch of coils. In the aforementioned specific example of the invention, the interannealing step is performed as a batch anneal by heating at a temperature between 300° and 350°C for about two hours.

The interannealing step of the invention is preferably followed by a further cold rolling stage, to reduce the workpiece (again, by at least about 30%) to the desired final sheet thickness. In the specific example of the presently preferred embodiment of the invention referred to above, this cold rolling operation reduces the sheet from 0.76 mm. to a final thickness of 0.1 mm., i.e. a cold reduction of about 87%.

The final sheet is then subjected to a final partial or full anneal, typically at a temperature between about 250° and about 400°C for a period of about two hours. In the aforementioned specific example of the invention, this step is performed as a

final partial anneal, by heating the sheet at a temperature between 300° and 350°C for two hours.

The product of the invention, produced as described above, has a fine grain or subgrain size and is a formable sheet (with Al-Mn intermetallic particles having an average particle size between 0.1 and two microns) having a controlled partial-anneal response (i.e. a high recrystallization temperature) and a shallow (low-slope) curve of yield strength as plotted against annealing temperature, thereby achieving a good combination of yield strength and ductility. The process of the invention can be practdiced to produce sheet having a combination of strength and formability essentially equivalent to commonly used foil alloys produced from conventional thick direct chill-cast ingot by successive hot and cold rolling operations. It is also possible, for example by performing the final anneal at a lower temperature, to achieve sheet having a higher yield strength with very little sacrifice in formability. Sheet products of the invention have been found to be very satisfactory for the manufacture of rigid foil containers and deep-drawn cooking utensils.

Performance of the non-recrystallizing interannealing step between successive stages of cold rolling is esssential for production of a fine grain fully annealed sheet. Interannealing under

non-recrystallizing conditions is also necessary when the material is to be reduced to foil (0.15 mm. and lower) for attainment of the beneficial result of the invention. In the case of sheet products where the reduction is less severe, and which are to be given only a partial final anneal, such an interannealing step between successive cold rolling stages tends to improve the product by enhancing ductility. Nevertheless, the interannealed material, without the subsequent cold rolling and final annealing step, itself constitutes a useful product for various purposes. Thus a useful sheet product can be made by performing the successive steps of strip casting an alloy of the specified composition, slab annealing, cold working to a desired final thickness and interannealing at final thickness but omitting the operations of cold rolling and final annealing after interannealing. In such case, the "interanneal" is in effect a final partial anneal of the cold-rolled product sheet.

The term "average particle size", as used herein, refers to the average particle diameter as determined, for example, by the procedure set forth in U.S. Patent No. 3,989,548.

By way of further illustration of the invention, reference may be had to the following specific examples:

EXAMPLE 1

An Al-Mn alloy containing 1.7% Mn, 0.2% Fe, 0.1% Si, and 0.03% Ti (grain refiner) was cast as 7.6 mm. thick slab on a twin-roll caster manufactured by Hunter Engineering Company. Separate coils of the as-cast slab were slab-annealed by heating, then cold rolled from the 7.6 mm. as-cast thickness to 0.76 mm. (90% reduction), interannealed, further cold rolled to a final foil thickness of 0.09 mm. and finally annealed. The thermal treatments (slab annealing, interannealing, and final annealing) were varied from coil to coil, but were all performed in accordance with the process of the invention, to provide a total of four coils (A-1, A-2, B-1 and B-2) representing sheet products of the invention produced with the differing specific combinations of thermal treatments specified in Table 1 below.

After the slab-anneal stage specimens were examined to check that the contemplated interanneal (temperature/time) conditions were below the recrystallization temperature for the material under examination.

TABLE 1

Temperature (°C) and Time

Coil	Slab Annealing	Interannealing	Final Annealing
A-1	500° (2 hr.)	400° (2 hr.)	300° (2 hr.)
A-2	" "	" "	400° "
B-1	525° (6 hr.)	350° "	300° "
B-2	" "	" "	400° "

Upon examination, it was found that the grain or subgrain size of the sheet thus produced was less than 25 microns and that the average intermetallic particle size of the intermetallics was less than two microns and the sheet was essentially free of coarse intermetallic particles. After the slab annealing stage the average intermetallic particle size was estimated at about 0.5 microns and in the subsequent interannealing and final annealing the size of these particles increased in a controlled manner.

Sheet from all four coils was formed into rigid foil containers, using production dies, with no difficulty.

Properties of the four coils A-1, A-2, B-1 and B-2 produced in accordance with the invention are set forth in the following Table II:

TABLE II

Coil	Orientation[1]	Ultimate Tensile Strength (kg/mm^2)	Yield Strength (kg/mm^2)	Elongation (%)	Erichsen[2] (mm)
A-1	L	13.8	9.8	14	7.1
	T	13.9	10.1	22	
	45	12.4	9.3	17	
B-1	L	13.9	8.7	17	7.1
	T	13.4	9.0	17	
	45	12.0	8.7	22	
A-2	L	12.4	5.1	18	7.6
	T	12.2	5.0	24	
	45	11.1	4.9	26	
B-2	L	12.7	4.9	20	7.4
	T	12.4	4.9	23	
	45	11.4	5.0	22	

[1] L = longitudinal, T = transverse, 45 = 45°

[2] A cupping test in which a piece of sheet metal, restrained except at the centre, is deformed by a cone-shaped spherical-end plunger until fracture occurs. The height of the cup in millimetres (or inches) at fracture is a measure of the ductility. The test is described in the British Standards Institute B.X. 3855; 1965: entitled "Method for Modified Erichsen Cupping Test for Sheet and Strip Metal".

For further comparison the properties of a standard .09 mm fully annealed foil, produced from Al 1.1% Mn alloy by the conventional procedure of casting as a thick, direct chill ingot and subjected to reduction by hot rolling and cold rolling is as follows:

Ultimate Tensile Strength	9.8 - 11.2 kg/mm^2
Yield Strength	3.8 - 5.2 kg/mm^2
Elongation	16 - 22%
Erichsen	7.1 - 7.4 mm

The figure of the drawing is a graph on which average yield strength is plotted against annealing temperature for the alloy represented by coil B with the values set forth in Table II above averaged and with values obtained for other annealing temperatures. This graph illustrates a shallow (low-slope) curve for yield strength plotted against annealing temperature, which is characteristic of sheet produced in accordance with the invention.

EXAMPLE II

Slabs 7,5 mm thick of alloys having the following compositions were cast using a twin-roll caster:

	Alloy D	Alloy E
Fe	0.20%	0.30%
Mn	1.64	1.47
Si	0.10	0.08
others (each)	less than 0.03	less than 0.03
Al	balance	balance

Each slab was slab annealed for two hours at 500°C, cold rolled from 7.5 mm to 3.8 mm (49% reduction), then subjected to a non-recrystallizing interanneal

by heating at 400°C for two hours, again cold rolled from 3.8 mm to 2 mm, and given a final partial anneal at 400°C for two hours. Properties of the produced sheet are set forth in Table III.

TABLE III

Alloy	Orientation	Ultimate Tensile Strength (kg/mm^2)	Yield Strength (kg/mm^2)	Elongation (%)	Erichsen (mm)
D	L	14.0	9.8	22	11.7
	T	14.0	10.5	17	
E	L	13.4	8.4	25	11.9
	T	13.4	9.9	21	

The Al-Mn intermetallic particle sizes both after the slab-anneal and interanneal treatment were similar to those found in the product of Example 1. The sheet produced exhibited a similar fine grain structure.

CLAIMS.

1. A process for producing an aluminium alloy sheet, comprising the successive steps of

(a) strip-casting a slab having a thickness of no more than about 25 mm, of an aluminium alloy containing as essential ingredient 1.3 - 2.3% Mn, and optionally up to 0.5% each of Fe, Mg, and Cu, up to 0.3% Si, up to 2.0% Zn, less than 0.1% each of Zr, Cr, and Ti, other elements up to 0.3% each and up to 1.0% total, balance Al;

(b) slab annealing the material before performance of any cold reduction by heating for a time sufficient to precipitate at least 50% of the Mn content as intermetallic particles having an average particle size, at the completion of the slab annealing step, of 0.1 - 2 microns.

(c) cold rolling slab-annealed material to reduce its thickness by at least 30%.

(d) interannealing the cold-rolled material by heating it at a temperature below the recrystallization temperature for a time sufficient to reduce the residual Mn in solid solution to no more than 0.2% by weight of the Al matrix.

2. A process according to claim 1, further characterised in that the interannealed material is subjected to the further steps comprising

(e) further cold rolling one or more times for additionally reducing its thickness to provide a sheet of desired final thickness and

(f) annealing the material after each further cold rolling stage.

3. A process according to claim 1 or 2 further characterised in that the slab annealing is carried out at a temperature in the range of about 450°C to about 550°C.

4. A process according to claim 1, 2 or 3 further characterised in that the casting step is performed by continuously casting the workpiece between chilled rolls, which also effect hot-reduction of the cast metal to generate residual strain.

5. A process according to claim 1 further characterised in that the cast slab is subjected to hot rolling before the slab-anneal treatment.

6. A process according to any of claims 1 to 5, wherein the Mn and Fe content of the alloy is held in the range 1.5 - 1.8% Mn, 0.1 - 0.3% Fe.

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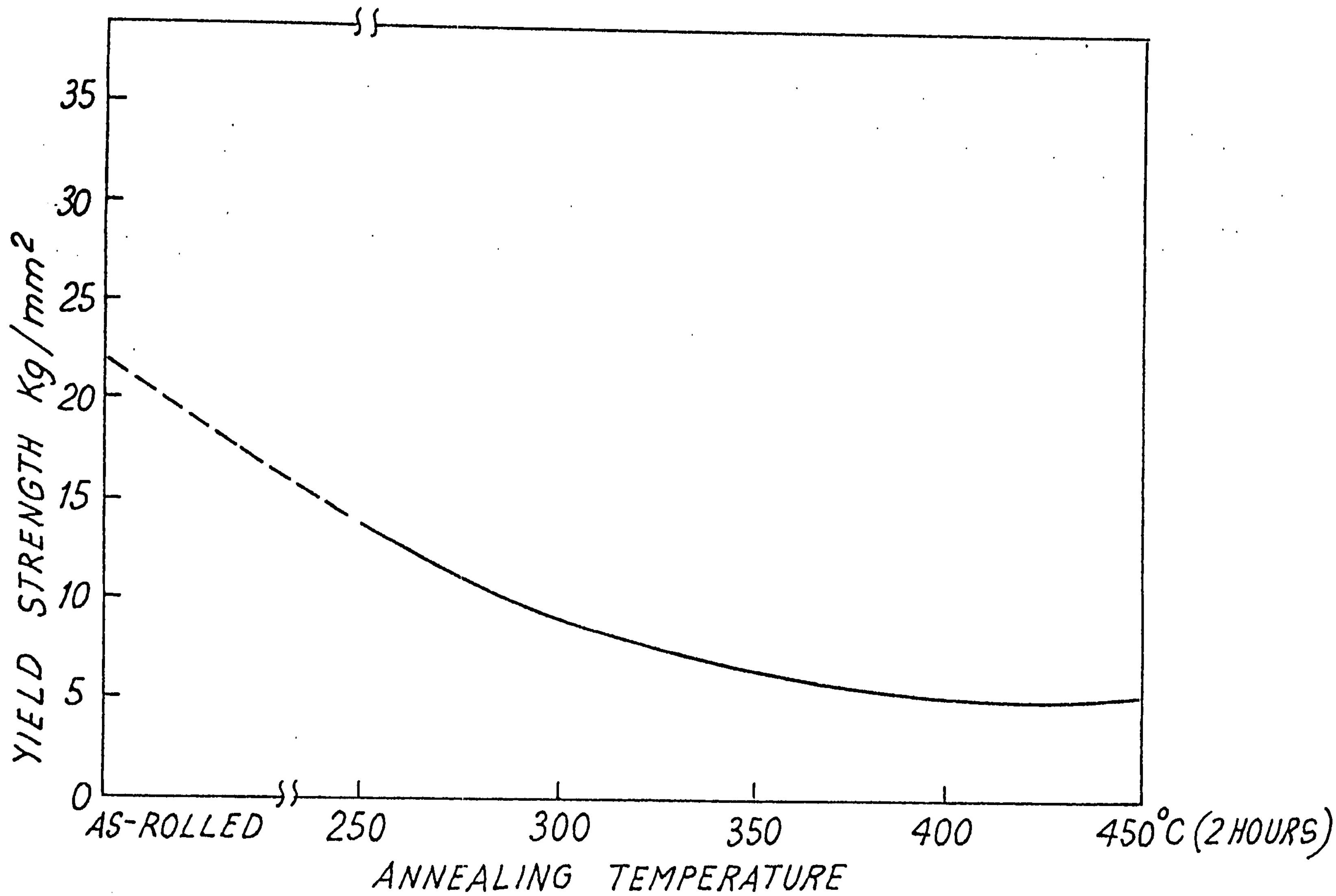

YIELD STRENGTH Kg/mm²
0
5
10
15
20
25
30
35
AS-ROLLED
250
300
350
400
450°C (2 HOURS)
ANNEALING TEMPERATURE

European Patent Office

EUROPEAN SEARCH REPORT

0039211
Application number
EP 81 30 1801

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim
	GB - A - 1 178 966 (ALCAN RESEARCH)	
	* Claims 1,4,6,8,9;	1,6
	page 1, lines 48-65;	3
	page 2, lines 28-32;	
	page 2, lines 73-93;	
	page 2, lines 97-110, claim 8 *	2
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	FR - A - 2 355 084 (AMERICAN CAN. COMP.)	
	* Claims 1,2,3,5,13,	1,2
	claim 6 ;	3
	page 5, lines 21-30; page 2, lines 35-38; page 3, lines 1-26 *	
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	FR - A - 2 411 244 (METALLGESELL-SCHAFT)	1
	* Claim 1 *	
	--	
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	* Claim 1 *	
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A	US - A - 3 219 491 (ANDERSON)	
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A	US - A - 3 486 947 (PRYOR)	
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D	GB - A - 1 549 241 (ALCAN)	
	* The whole document *	
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CLASSIFICATION OF THE APPLICATION (Int Cl.³)

C 22 F 1/04

TECHNICAL FIELDS SEARCHED (Int. Cl.³)

C 22 F
B 22 D

CATEGORY OF CITED DOCUMENTS

X: particularly relevant
A: technological background
O: non-written disclosure
P: intermediate document
T: theory or principle underlying the invention
E: conflicting application
D: document cited in the application
L: citation for other reasons

&: member of the same patent family, corresponding document

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	07-08-1981	RIES

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European Patent Office

EUROPEAN SEARCH REPORT

Application number
EP 81 30 1801
-2-

DOCUMENTS CONSIDERED TO BE RELEVANT			CLASSIFICATION OF THE APPLICATION (Int. Cl.3)
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	
D	US - A - 4 111 721 (HITCHLER) * Whole document * --		
D	US - A - 3 930 895 (MOSER) * Whole document * --		
D	US - A - 3 989 548 (MORRIS) * Whole document * --		TECHNICAL FIELDS SEARCHED (Int. Cl.3)
D	US - A - 3 570 586 (LAUENER) * Whole document * ----		